Modeling Renal Function During Pregnancy

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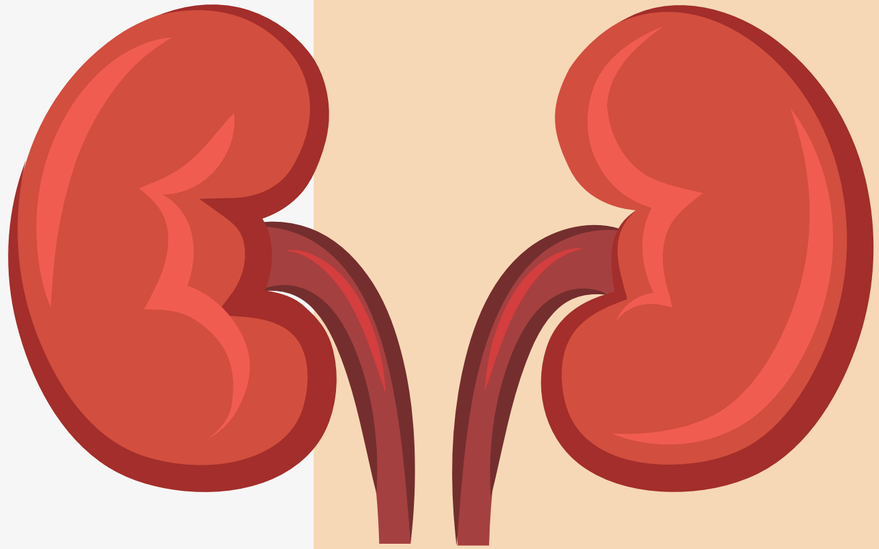
~Objective~

To build a computational model that illustrates the main processes in renal function during pregnancy.



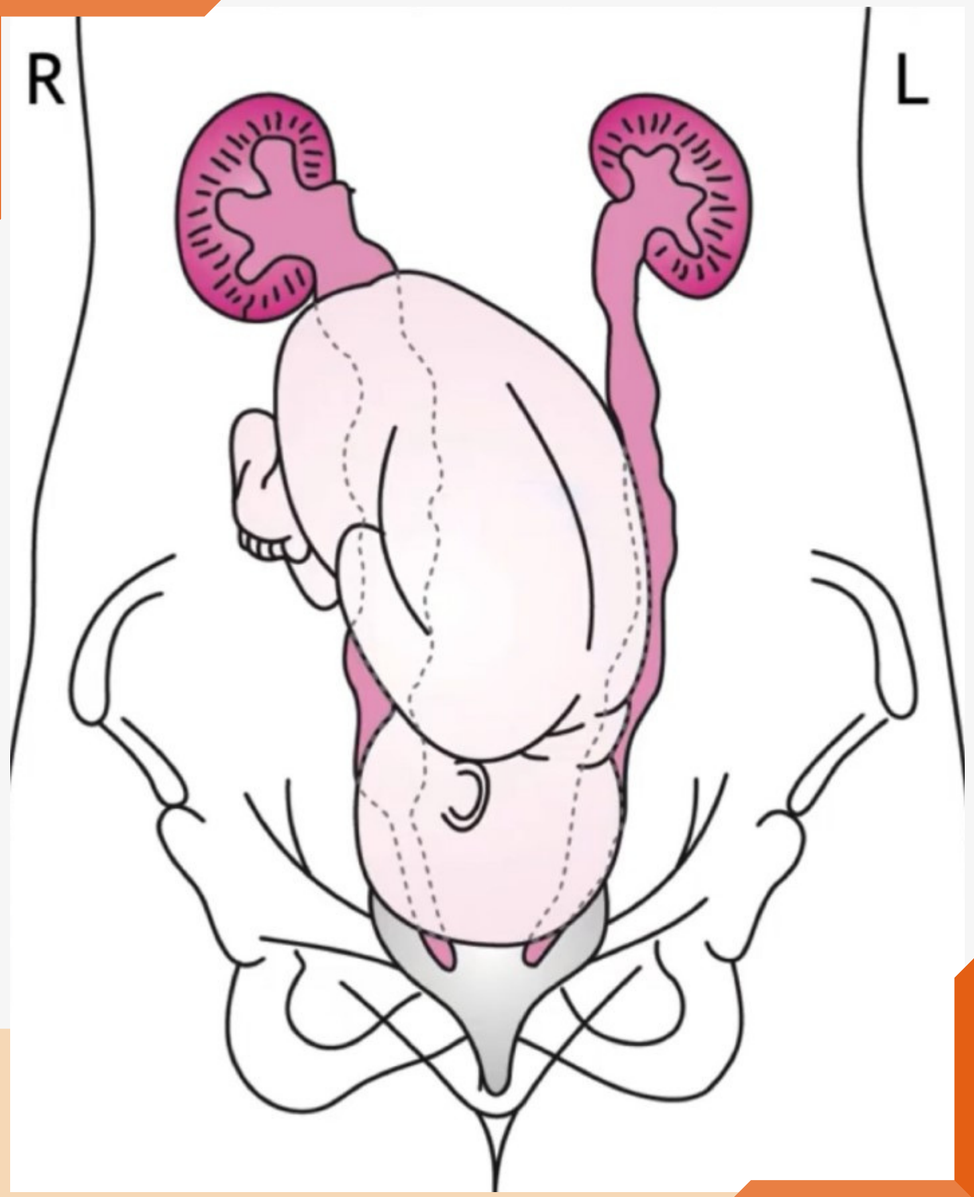
~Background~

- The renal system is a central part of pregnancy
- Modeling its processes help understand how they may be affected through pregnancy

Baylis. P. H., Davison, J. M., Moran, P., & Lindheimer, M. D. (2002).
Cheung. K.L., and Lafayette. R.A. (2013).
Christensen, E. I., Edwards, A., Norden, A. G. W., & Unwin, R. J. (2021).

~Background~

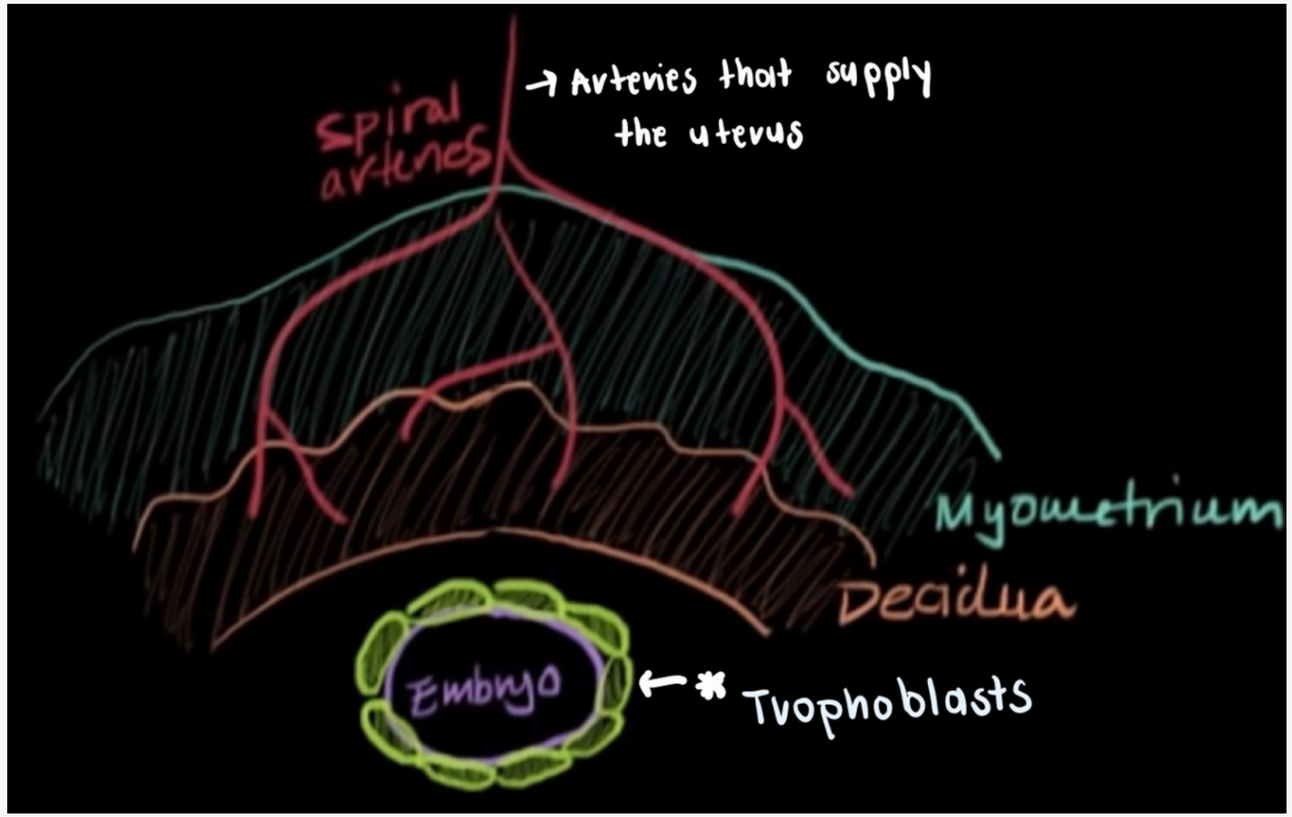
- Changes in size
- Displacement of ureters to support the fetus
- Increase in glomerular filtration rate and renal plasma flow



Modern ObGyn (2018).

~Background~

- Preeclampsia is a major complication in pregnancy
- Characterized by hypertension, proteinuria and organ damage
- Caused by abnormal placental blood vessel development
- Symptoms resolved through pre-term birth

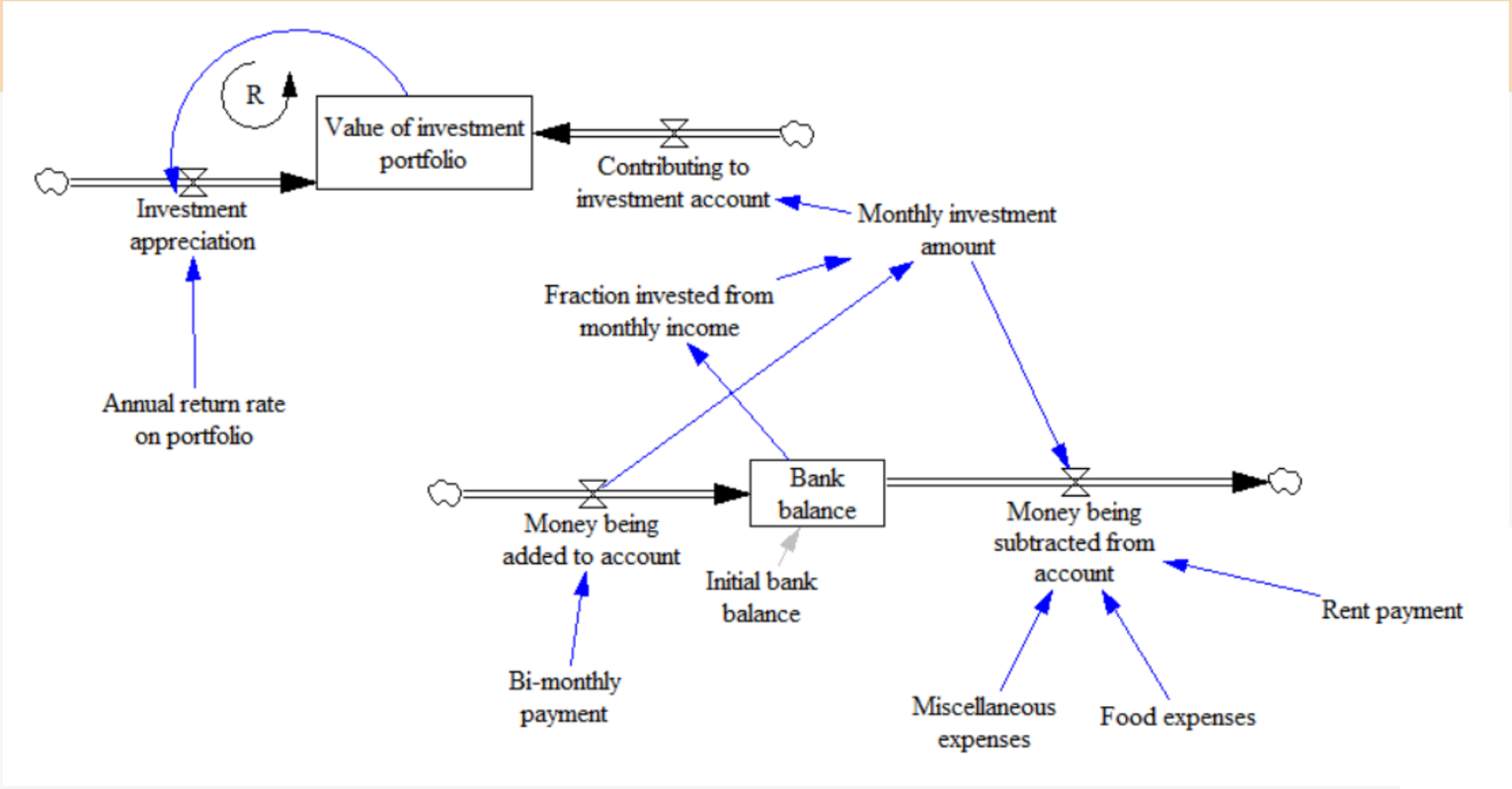


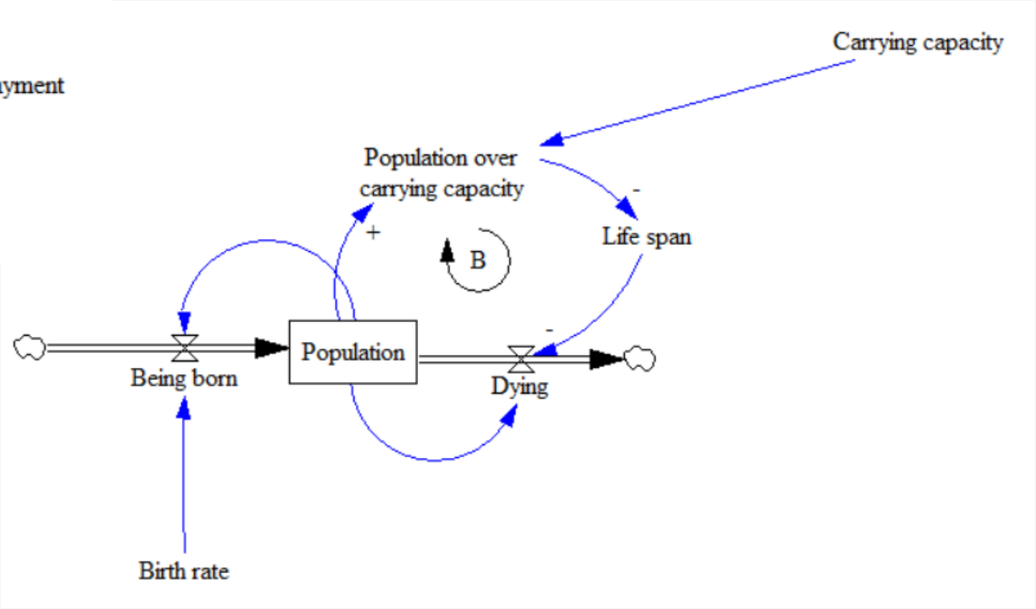
Khanacademymedicine (2015).

~Method: Initial Literature Research and Vensim~

- **Main focus:** To learn basics in Vensim and renal physiology through pregnancy
- Check-in with mentor three to four times a week
- Build simple models on real life situations

~Method: Initial Vensim Models~

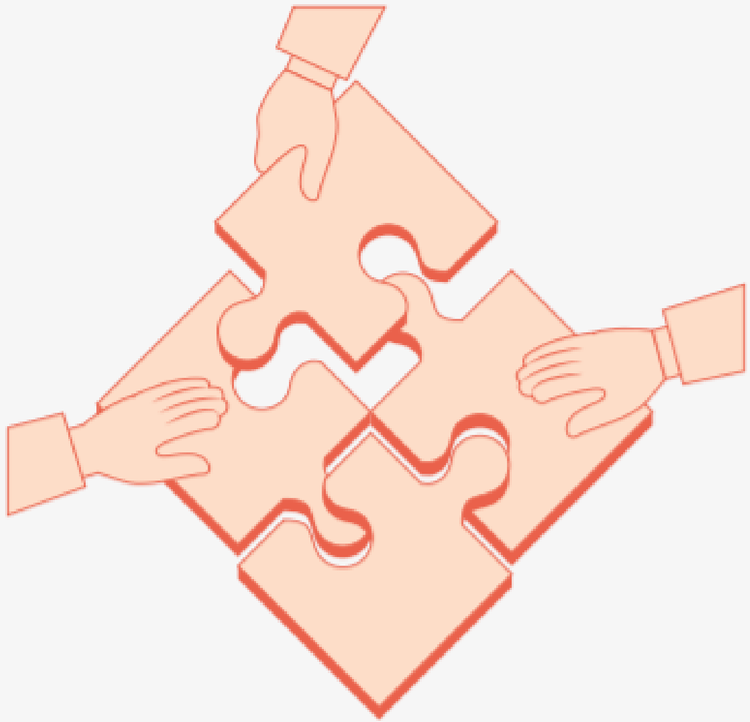


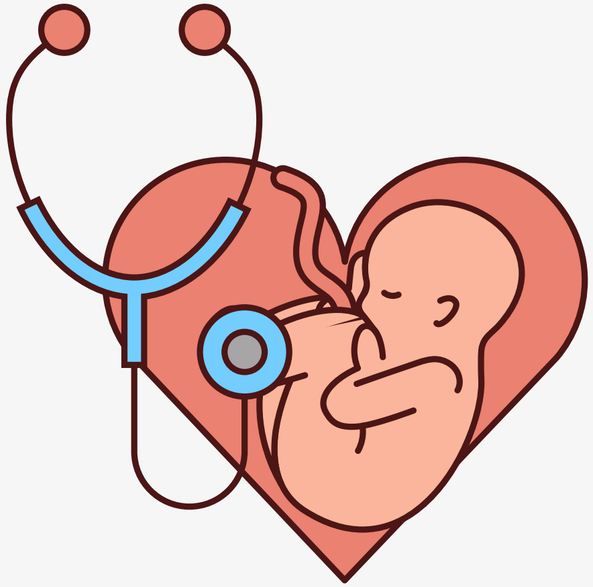


~Method: Initial Literature Research and Vensim~

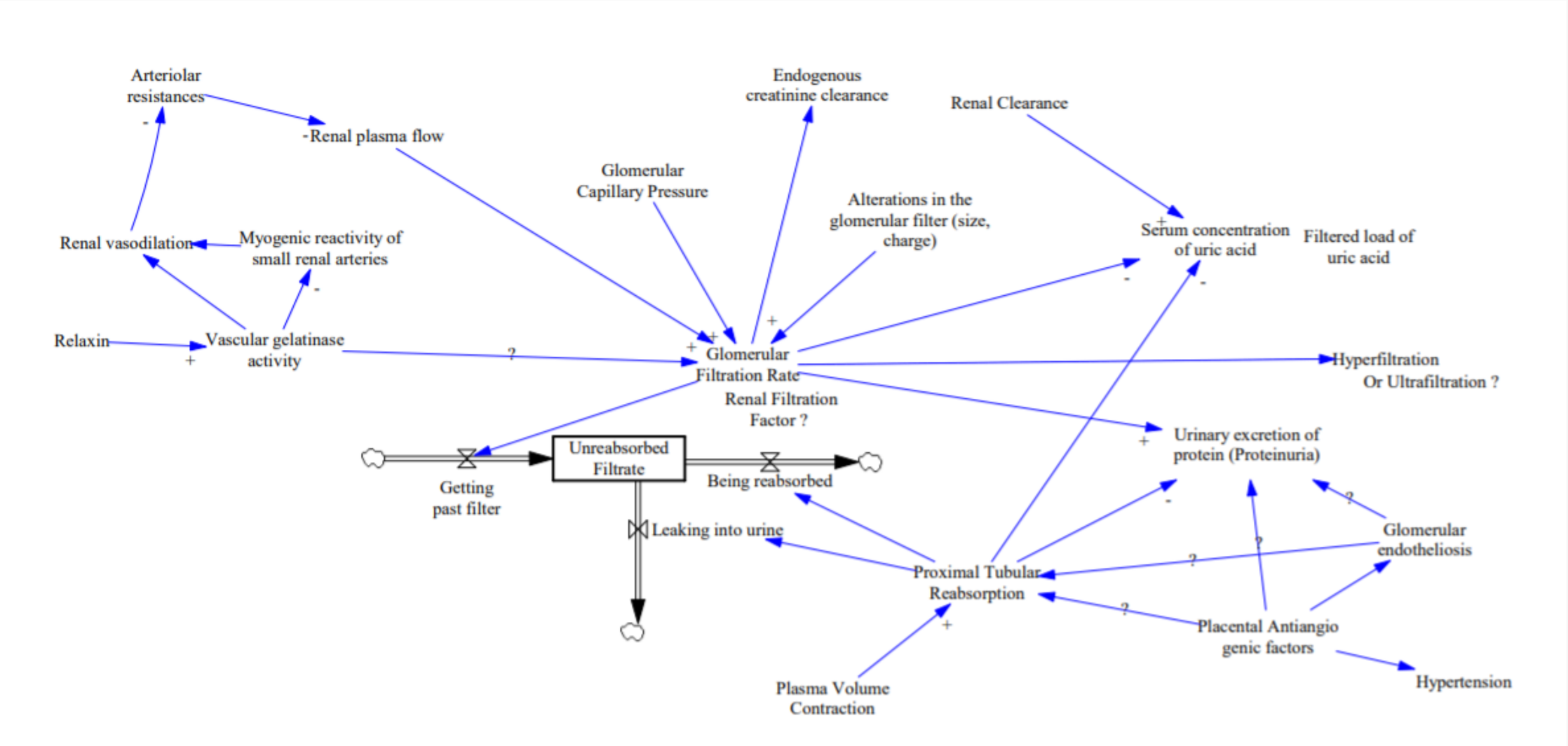
- Read research literature provided by research team
- Analyze basic renal functioning concepts
- Outside research

~Method: Incorporating resources together~





~Method: Initial Renal Function Diagram~



Bia, D., Sosa, C., Torrado, J., Pereira, M, P., & Zocalo, Y. (2021).

Conrad. K. P. Jeyabalan. A. (2007).

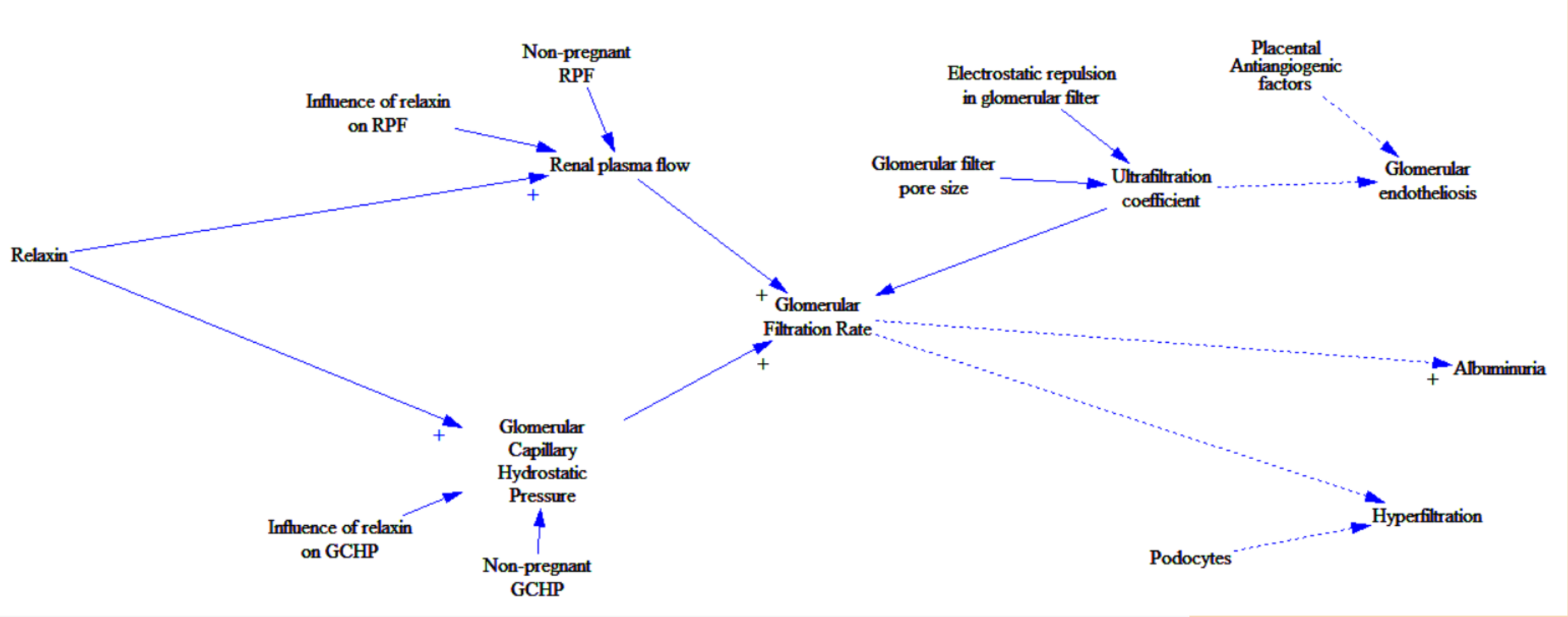
~Method: Renal Function Diagram~

Choosing a starting point

Reaching out to experts

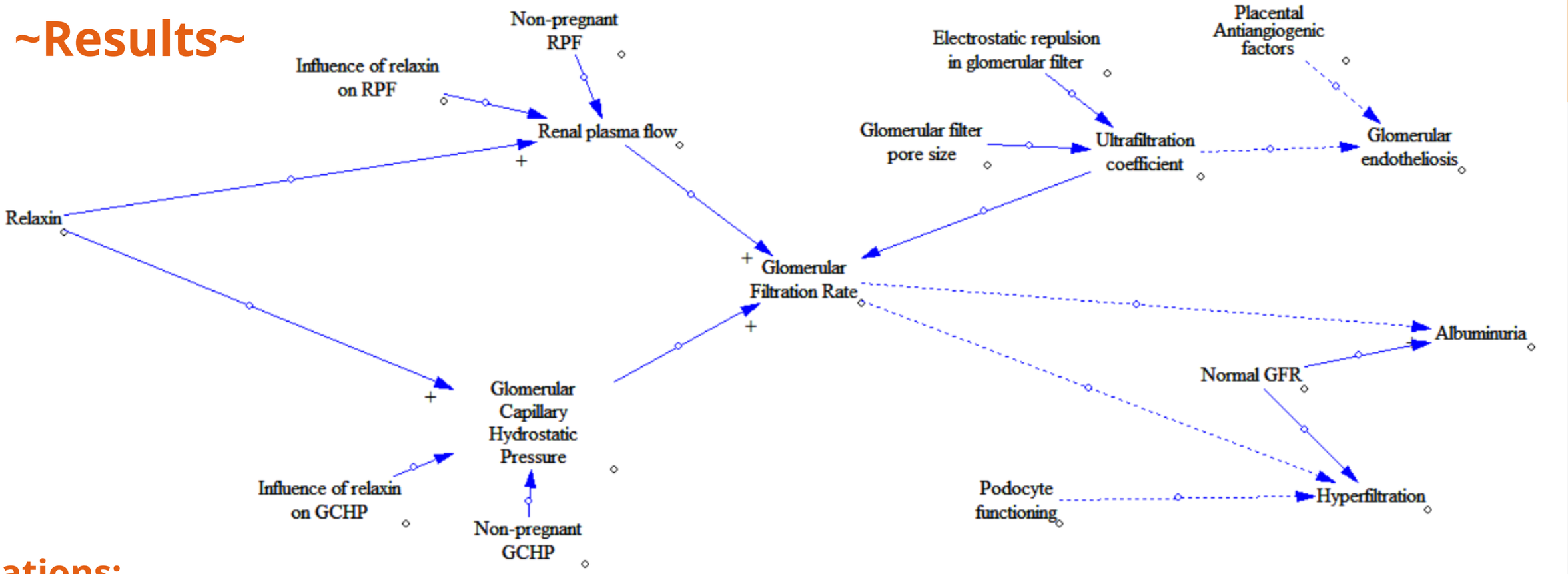
Going back to basics

~Method: Renal Function Diagram~



Garmire, L., McElrath, T. F., Myatt, L., Rich-Edwards, J. W., Roberts, J. M., & Global Pregnancy Collaboration. (2021).
Redman C. W. G., Roberts, J. M., & Staff A. C. (2020).

~Results~



Equations:

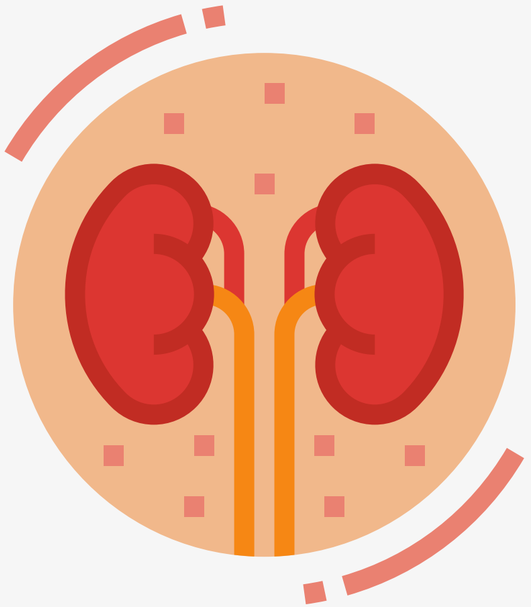
Glomerular Filtration Rate = Ultrafiltration coefficient * Glomerular Capillary Hydrostatic Pressure * Renal plasma flow - Units: ml/min

Renal plasma flow = "Non-pregnant RPF"*(1+Influence of relaxin on RPF*Relaxin) - Units: ml/min

Glomerular Capillary Hydrostatic Pressure = "Non-pregnant GCHP"*(1+Influence of relaxin on GCHP*Relaxin) - Units: mmHg

Albuminuria = IF THEN ELSE(Glomerular Filtration Rate > 2 * Normal GFR , 1 , 0) - Units: mg/d

~In Conclusion~



- Comparing pregnant vs non-pregnant values help to illustrate how pathologies develop
- Help to incorporate detail into more complex model
- Skills learned helped me grow as a researcher

~Acknowledgements~

Dr. Wayne Wakeland, Dr. Arie Baratt, Dr. Susan Bagby, Dr. Leslie Myatt, Dr. James Roberts, Mikhail Mints, Dr.Christof Teuscher, Dr. Philippe Proctor, and Adrian Jimenez.

~References~

Baylis. P. H., Davison, J. M., Moran, P., & Lindheimer, M. D. (2002). Glomerular Ultrafiltration in Normal and Preeclamptic Pregnancy. Journal of the American Society of Nephrology 648-652.

Bia, D., Sosa, C., Torrado, J., Pereira, M, P., & Zocalo, Y. (2021). Role of arterial impairment in preeclampsia: should the paradigm shift?. American Journal of Physiology, Heart and Circulatory Physiology.

Cheung. K.L., and Lafayette. R.A. (2013). Renal Physiology of Pregnancy. Division of Nephrology, Stanford University.

Christensen, E. I., Edwards, A., Norden, A. G. W., & Unwin, R. J. (2021). Predicting the protein composition of human urine in normal and pathological states: Quantitative description based on Dent 1 disease (CLCN5 mutation). The Journal of Physiology 599.1 pp 323-241.

Garmire, L., McElrath, T. F., Myatt, L., Rich-Edwards, J. W., Roberts, J. M., & Global Pregnancy Collaboration. (2021). Subtypes of Preeclampsia, Recognition and Determining Clinical Usefulness. Department of Obstetrics Gynecology and Reproductive Sciences, Epidemiology and Clinical and Translational Research, Magee-Womens Research Institute, University of Pittsburgh 1430-1441.

Redman C. W. G., Roberts, J. M., & Staff A. C. (2020). Syncytiotrophoblast stress in preeclampsia: the convergence point for multiple pathways. Nuffield Department of Women's Reproductive Health, University of Oxford, Faculty of Medicine, University of Oslo, and Magee-Womens Research Institute and Foundation.